Performance studies of KM3NeT-ORCA for dark matter detection with low energy neutrinos

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Goal & motivation

- Study efficiency of KM3NeT-ORCA detector
- Determine detector effective area/acceptance and resolution
- Effective detector acceptance (A_{eff}) important for Dark Matter search
- Expected event per energy and angular bin from DM decay:

$$N_{i,j} = \int_i dE_{\text{obs}} \int_j d\Omega \frac{dI}{dE_\nu} \frac{dE_\nu}{dE_{\text{obs}}} \boldsymbol{A_{\text{eff}}} \, T \left\langle e^{-\tau(E_\nu)} \right\rangle$$

- **Motivation:** Study the detector performance (resolution, efficiency) and acceptance for ORCA

Data files & cuts

- Data from summary files (PID)
- JGandalf for track events, Dusj for shower events
- Loose cuts for track: angle between simulated and reconstructed direction, likelihood and β_0 (error on angular reconstruction)
- Both type of events are cut on track-like score: > 0.6 for track (tight cuts) and < 0.6 for shower (quality cuts)

Effective detector acceptance

- Different for each neutrino type
- Relates rate of detected particles R and incident neutrino flux Φ in a given solid angle Ω and time

$$R(E_\nu, \Omega) = A_{\text{eff}}(E_\nu, \Omega) \times \Phi(E_\nu, \Omega)$$

- In this study calculated by:

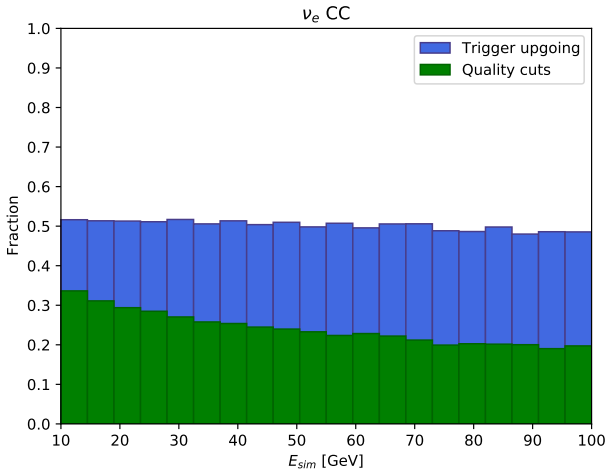
$$A_{\text{eff}}^{\text{bin}} = \frac{1-\gamma}{\Omega\, T\, N_{gen}} \frac{\sum_i w_i\, \Phi(E_\nu)}{E_{max}^{1-\gamma} - E_{min}^{1-\gamma}},$$

where w_i is a weight to correct for simulated events[1].

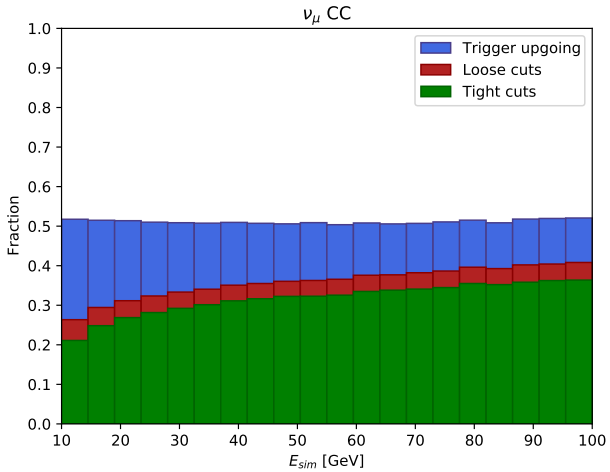
[1] gSeaGen

Results - Selection efficiency

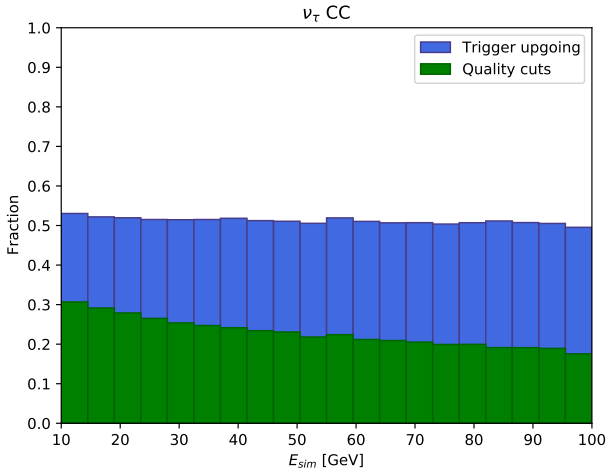
- Fraction of events after selection



(a)

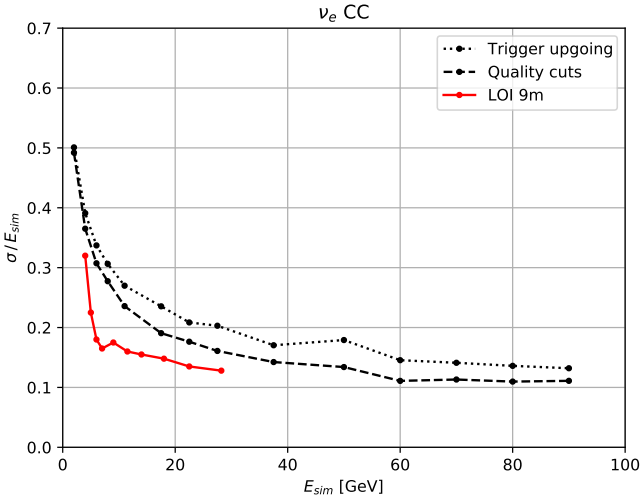


(b)

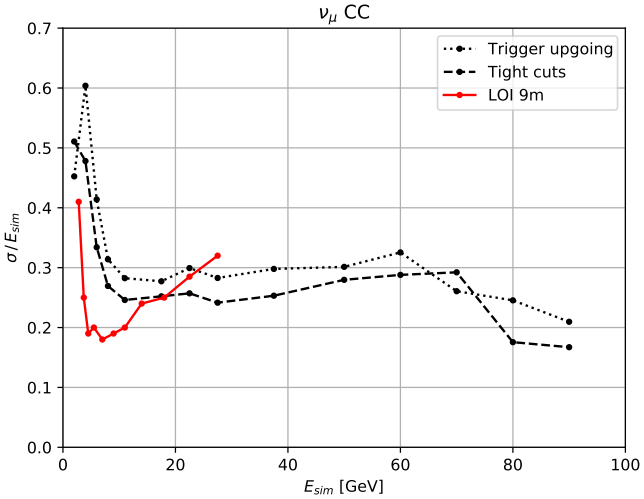


(c)

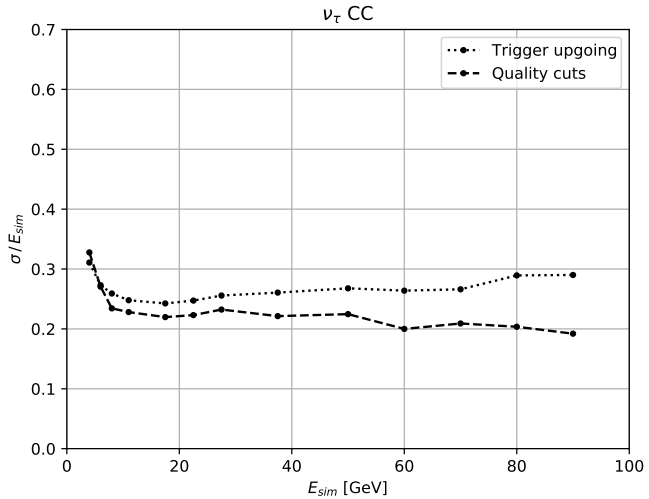
Results - Energy resolution



(a)

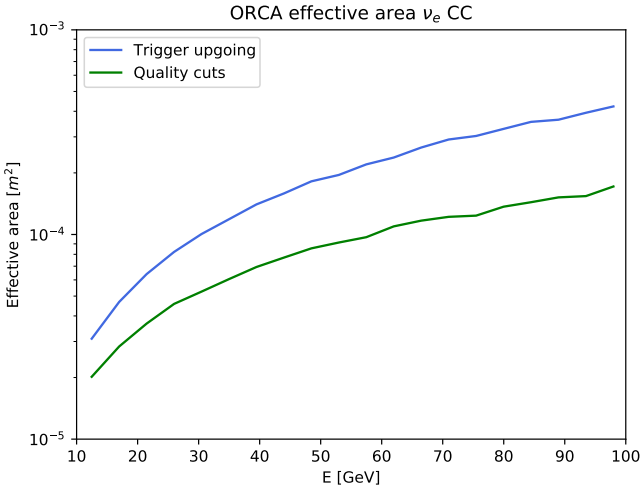


(b)

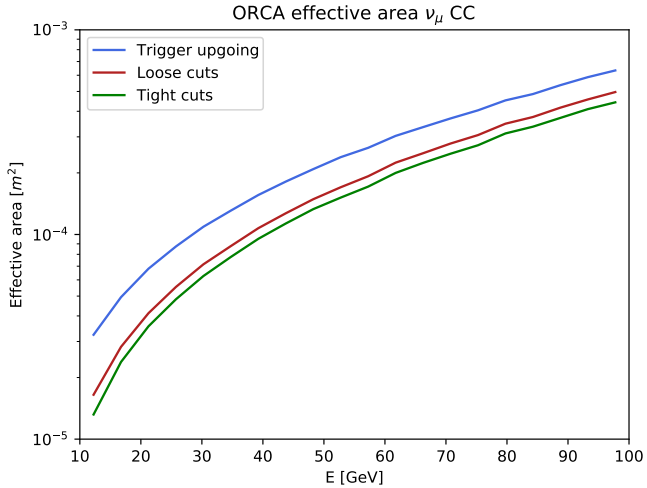


(c)

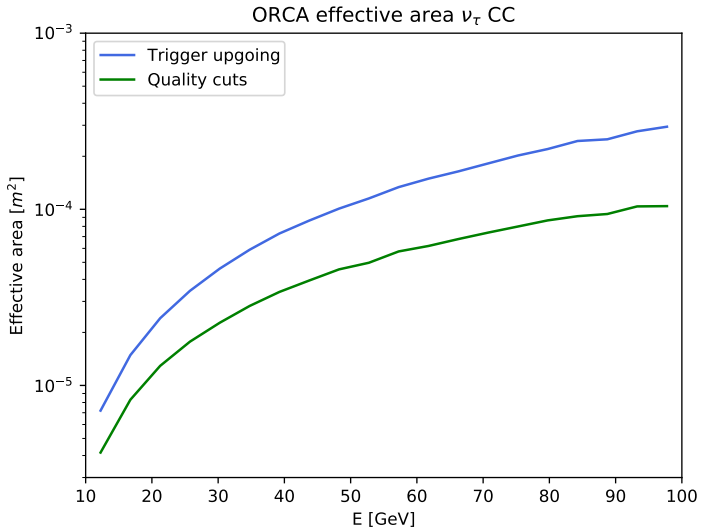
Results - Effective area



(a)

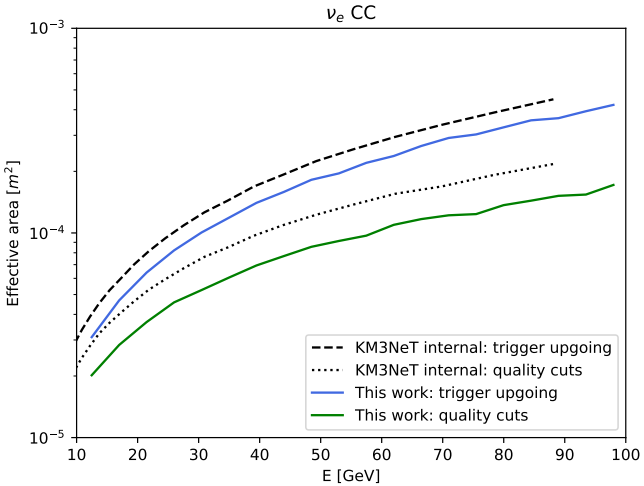


(b)

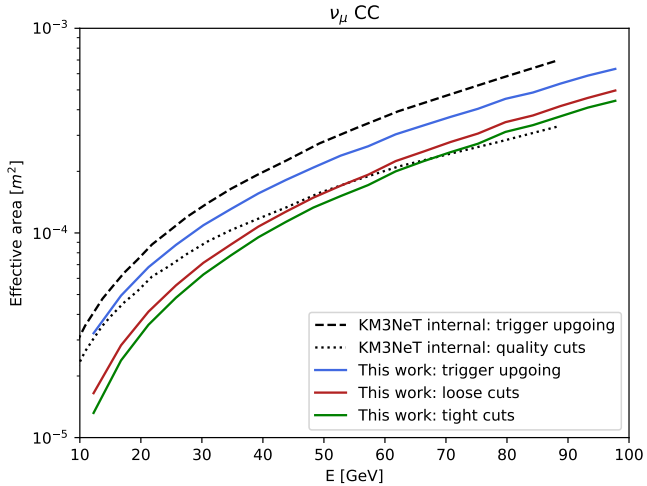


(c)

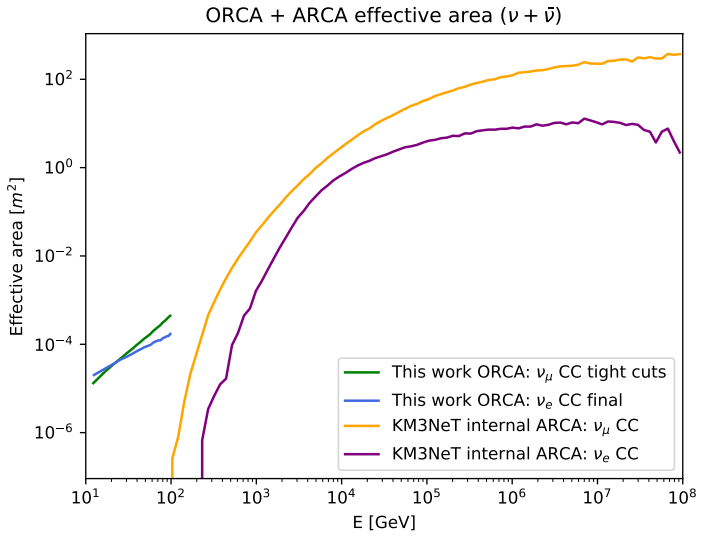
Results - Comparisons



(a)

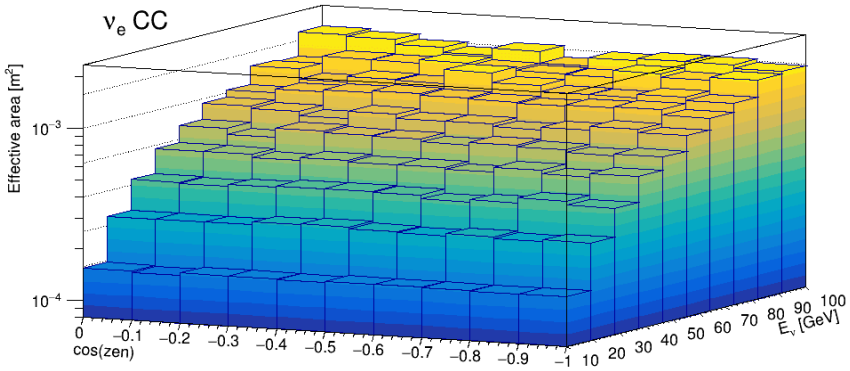


(b)

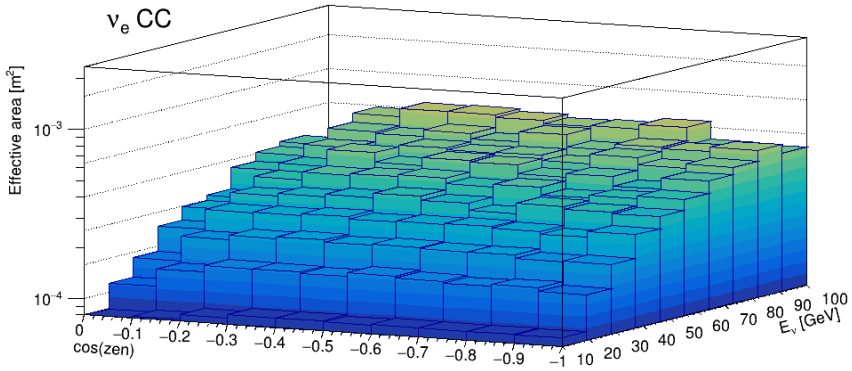


(c)

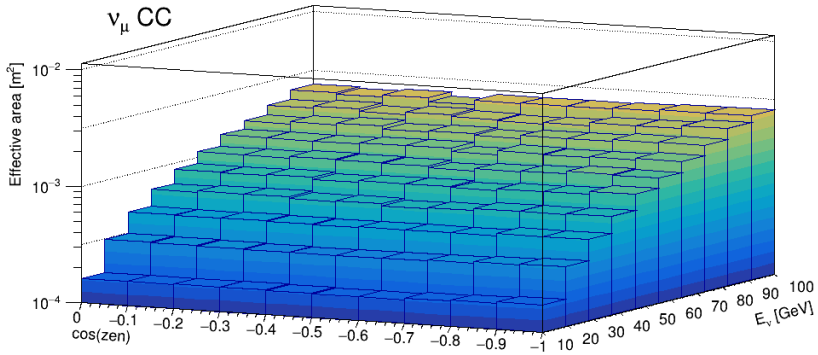
Results - 2D effective area e and μ



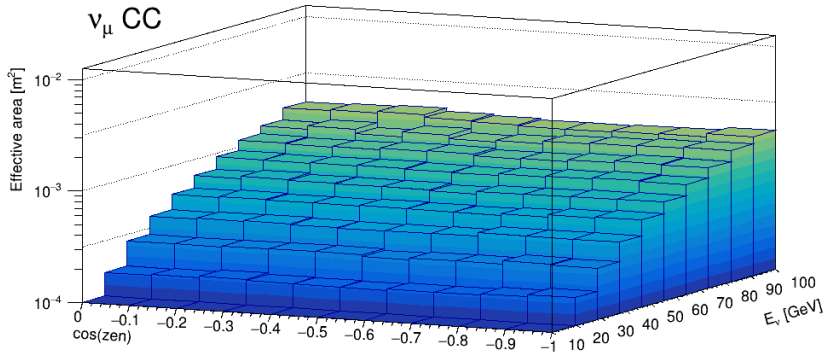
(a) ν_e trigger upgoing



(b) ν_e quality cuts

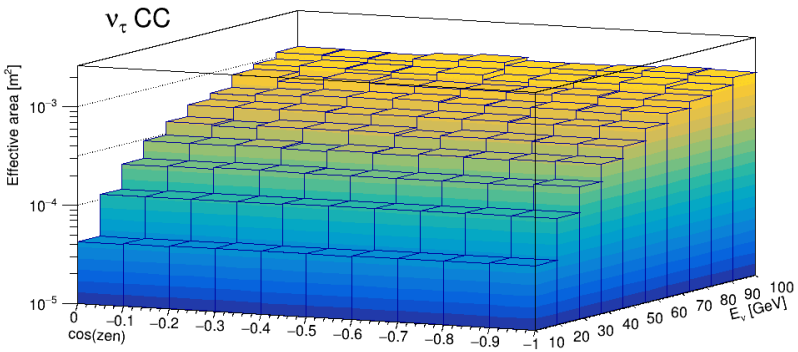


(c) ν_μ trigger upgoing

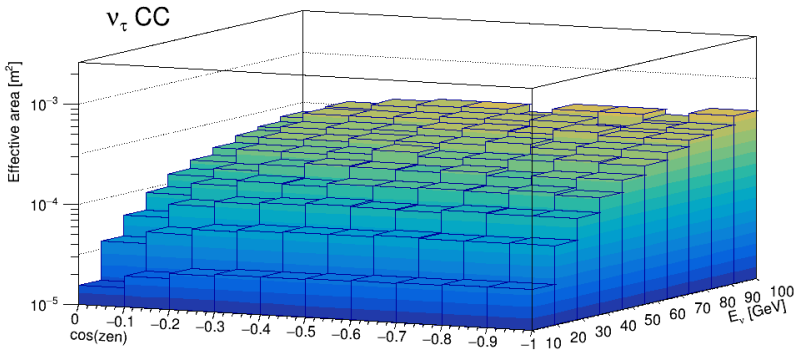


(d) ν_μ tight cuts

Results - 2D effective area τ



(a) ν_τ trigger upgoing



(b) ν_τ quality cuts

Conclusion

- Effective acceptances for ν_e, ν_μ and ν_τ have been determined for KM3NeT-ORCA
- Obtained effective acceptance for energy and zenith angle
- Still require optimizations for event selection and detailed study
- This study independently cross-checks other studies in KM3NeT

References

- Kenny Ng et al., Sensitivities of KM3NeT on decaying dark matter. arXiv:2007.03692
- KM3NeT Collaboration. "gSeaGen: the KM3NeT GENIE-based code for neutrino telescopes". In: 2020. arXiv:2003.14040